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Identity: The Key to Insect Control

All of science is tentative. Today's facts must always be qualified. "To the best of our knowledge," "from what we have seen today," or "it appears," are common scientific phrases.

Scientists constantly reassess each other's discoveries. Almost daily, new findings put a different perspective on yesterday's research findings.

Previously, we assumed that the world was a simple place to live. Or, we refused to see the differences—a mental block of sorts.

But then, we once thought the world was flat.

Many areas of science began as hobbies. Science is still best done by those who enjoy what they're doing.

The hobby of bug collecting through the years has evolved into the precise science of entomology. Much of our early amateur taxonomic work on insects was done on a very superficial level—thus, names and insect descriptions are not always accurate.

ARS entomologists note that there are big gaps in our knowledge of the lepidoptera (moths) north of Mexico, for example.

More knowledge about insects is vital to our survival—they inhabit every area of our world. To effectively handle our needs for food, fiber, and timber we must know what insects and mites we're dealing with.

Most insect identification is based on adult insects. It is the immature stages, however, which do most of the agricultural damage. At best, entomologists can identify only 5 percent of insect larvae.

We must learn all we can about every insect. This information can tell us the insect's potential value or destructiveness. Such studies as those now being done by the ARS Systematic Entomology Laboratory (SEL) can help solve basic agricultural problems (see article on page 10).

The USDA insect collection includes nearly 24.5 million specimens. In a year's time, the 29 SEL entomologists identify between 250,000 and 350,000 insect and mite specimens.

These ARS entomologists serve not only the public, but all areas of agriculture. Accurate insect identification holds the key to greater production and effective control.—*M.M.M.*

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COVER: The land imprinter consists of two cylinders, from which 45 different patterns can be made. After it is waffled, semiarid land can capture and hold more rainfall (0277X174-29A). Article begins on page 6.

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Finding the Achilles Heel

The results of time lapse photomicrography are viewed by the research team using an analytical projector. The film is an image and clock giving a precise record of the size and position of each structural feature of the insect and the exact timing of cuticle development. This research may lead to ways of inhibiting an insect from growing a protective exoskeleton (0177X040–17A).

An insect's unique ability to grow a protective exoskeleton at molting could be its Achilles heel, a weakness to be exploited in selective control.

A dozen years ago such a selective control technique was at best an idea worth exploring. Scientists knew very little about how insects form chitin-bearing cuticle, the material making up the skeleton, so had few clues to how the process might be disrupted.

Basic research since 1964 by ARS entomologist Edwin P. Marks and others has now explained some key steps in the process. Most important, he has a tissue culture technique for study and experimental manipulation of cuticle deposition and for determining the mode of action of compounds that disrupt the process.

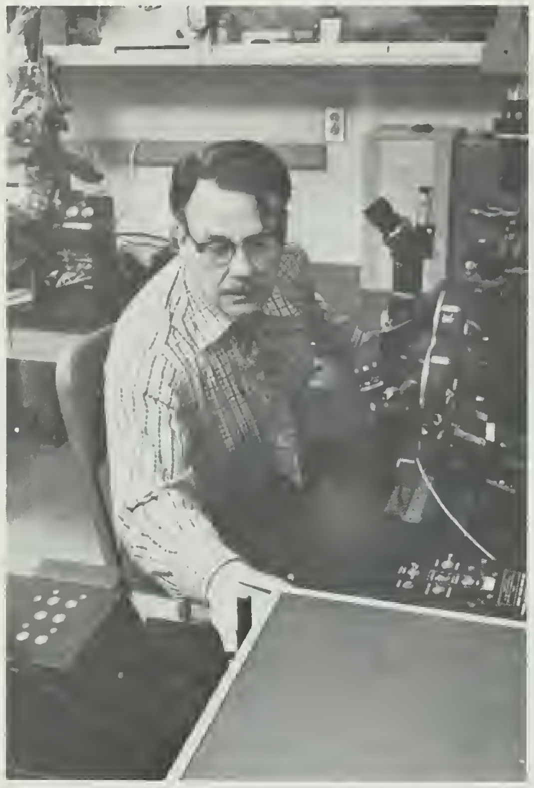
Using this technique, Dr. Marks and Blair A. Sowa, North Dakota State University, confirmed that Dimilin inhibits synthesis of chitin, which with protein makes up cuticle. Dimilin, formerly known as TH–6040, has shown promise for control of the gypsy moth and other insects.

In 1964 Dr. Marks at the Metabolism and Radiation Research Laboratory (P.O. Box 5674, Fargo, ND 58102), was asked to find out more about how insect cuticle is formed. He had earlier set a personal goal, when a Kansas college professor, of culturing tissues from the leg of the cockroach and studying the growth processes. Insect tissue culture techniques were then in their infancy; an Australian had first successfully grown insect cells *in vitro* in 1962.

Dr. Marks uses immature cockroaches, from which a pair of legs has been removed just after molting, as a source of tissue for study. The roach immediately starts growing replacements for the removed legs. When this regenerating tissue is transferred to a tube or chamber containing a threshold dose of molting hormone, complete although structurally imperfect cuticle forms on the surface in about 10 days.

Tissue culture has advantages over

Dr. Marks adjusts time lapse photomicrography unit used to film cuticle development. Usually a 1-second exposure is made every 5 minutes (0177X039–34).



***Above:** The insect is shown in the molting stage. The age of these lab insects is established from the date of molting. The new cuticle is white immediately after molting and remains so for about an hour (PN–4124).*

***Right:** A seta—a movable hair and socket—formed from two epidermal cells in response to treatment with the molting hormone. The seta rapidly becomes covered with cuticle (PN–4125).*

studies with living insects, Dr. Marks points out. A single organ can be observed in isolation, and changes can be visualized at the cellular level as they occur. Research on mode of action of compounds that interrupt cuticle formation would be much more difficult in living insects.

Progress was slow at first in this pioneering area of basic research. It wasn't until 1970 that Dr. Marks' attempts to produce cuticle *in vitro* were successful. Two years later he and ARS entomologist Roger A. Leopold confirmed that the molting hormone stimulates formation of a complete cuticle, containing chitin, in cultured leg tissue.

Earlier, Dr. Marks had found that insects' prothoracic glands do not produce the molting hormone, beta-ecdysone, but something else like it. Molting hormone was later proved essential in biosynthesis of both protein and chitin in cuticle formation.

Other studies revealed some of the intervening steps in synthesis of the hormone. First, another laboratory identified the compound produced by the glands as alpha-ecdysone. Then industry researcher David Shaw King and Dr. Marks demonstrated that cockroach tissues slowly convert alpha to the beta form. Tissues respond slowly when alpha-ecdysone is supplied because they are not stimulated by the alpha form as such but by beta-ecdysone after conversion takes place.

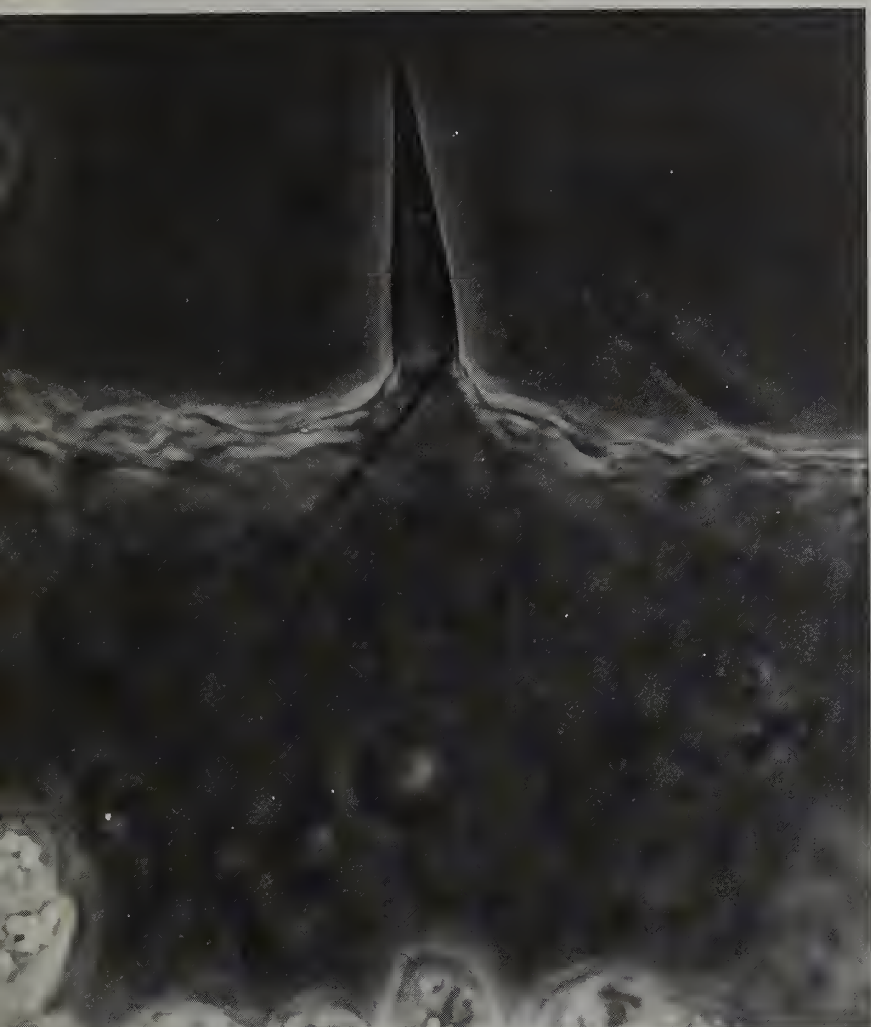
Time-lapse photomicrography studies then delineated the sequence and timing of events between activation of epidermal cells by the hormone and appearance of new chitin-bearing cuticle.

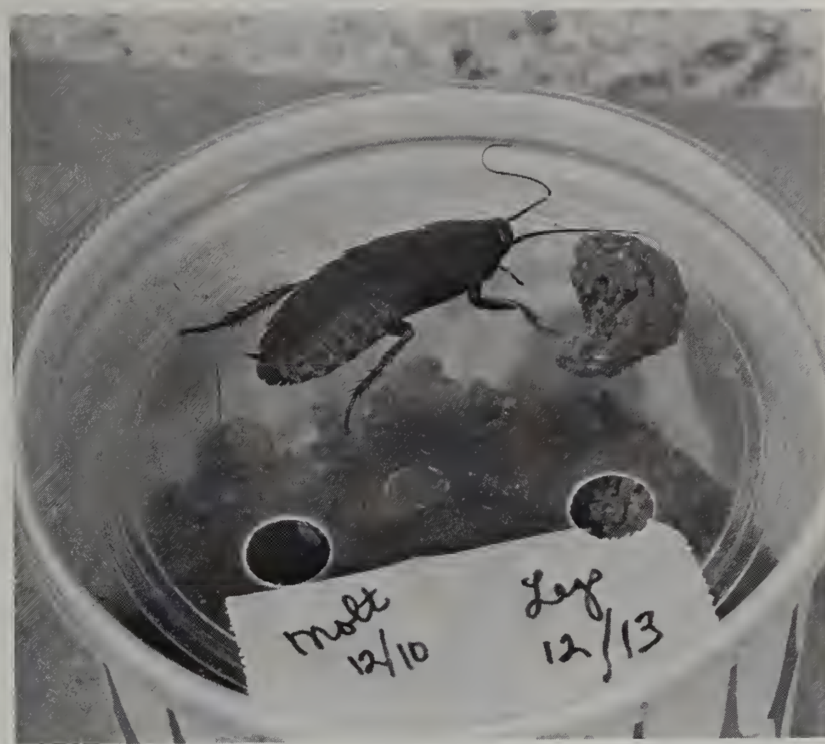
Preparation for the process—beta-ecdysone stimulation and biosynthesis of protein and chitin—required 4 days, and deposition of cuticle lasted no more than 2 days. The researchers found that the cells had differentiated by the fourth day, new cuticle was visible by the sixth day, and cuticle formation ceased by the end of the eighth day.

With the tissue culture system, Dr. Marks and associates had described cuticle formation about the same time that other scientists identified Dimilin as promising in control of several insects. Knowledge of exactly how it acted would give clues to how other, possibly more effective, compounds might be synthesized as well as identify potential hazards in their use.

Dr. Marks and Dr. Sowa compared Dimilin and polyoxin D, a fungicide developed in Japan and known to inhibit chitin synthesis. They found that the chemically dissimilar compounds neither stimulated cuticle deposition nor interfered with production of visible cuticle. However, both prevented chitin synthesis.

The compounds completely inhibited incorporation of radiolabeled material from which chitin is formed, N-acetyl glucosamine, into the cuticle.



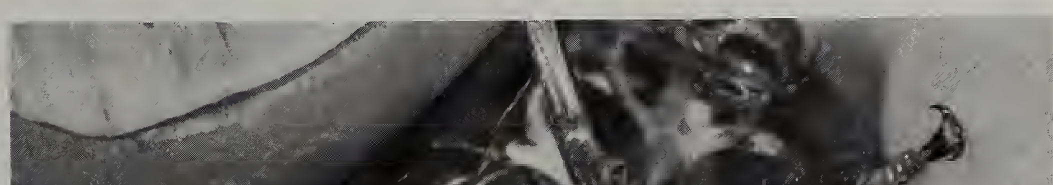


Above: Leucophaea maderae *(F.)—a South American cockroach used by Dr. Marks in cuticle formation research—is shown above in its laboratory environment. The molting date and the date the middle pair of legs was removed are shown on each insect cage (0177X041–11).* ***Below:*** *Following the removal of the middle pair of legs, new legs form in the stumps. Twenty-eight days after removal of the first pair, the regenerated pair is also removed and placed in a culture for cuticle formation (0177X037–14A).*

Dimilin has proved to be an extremely effective insecticide. Apparently, it concentrates in cultured insect tissue, thus multiplying its effective concentration, Dr. Marks says.

Further research is being carried out on the mode of action of Dimilin and other compounds that affect biosynthesis of chitin. Other polysaccharide compounds such as glycogen and hyaluronic acid also occur in vertebrates. The effect of these inhibitors on the biosynthesis of such compounds must also be investigated. This information will be necessary to develop new and specific insecticidal compounds that act by disrupting cuticle formation.

Extensive research of chitin synthesis inhibitors is being conducted by commercial firms. Much of this research employs the methods developed at the Metabolish and Radiation Research Laboratory from basic studies of how cuticle is formed by regenerating cockroach legs.—*W.W.M.*



The land imprinter is designed to increase infiltration and reduce runoff and evaporation. Acting as a small runoff control system, imprint "geometry" directs water to points in the pattern where seed is placed or vegetation is growing (0277X174–31A).

Tool for Water Conservation

An implement under development near Tombstone, Ariz., may be a means of changing a vicious cycle into a virtuous circle on semiarid rangelands.

Overgrazed, near-barren rangelands in the Southwest and elsewhere become increasingly more barren of forage grasses because of poor management practices.

The more barren of grasses the lands become, the more each rainfall seals the soil surface, leading to decreased infiltration and increased runoff, evaporation, and erosion.

Soil scientist Robert M. Dixon, Southwest Rangeland Watershed Research Center (442 E. Seventh Street, Tucson, AZ 85705), has developed a "land imprinter" or circle plow that "waffles" these semiarid rangelands with geometric patterns designed to increase infiltration and reduce runoff and evaporation, thereby routing more rainwater to plant roots.

Barren land characteristically possesses relatively low infiltration rates—often as little as one-tenth that of grasslands. Bare soil sheds water readily, since it possesses well-developed surface drainage patterns and is sealed tightly by raindrops impacting on its surface.

The small amount of water that does infiltrate penetrates the soil so superficially that it is quickly lost by surface evaporation. Thus the vicious cycle sets in, driven by physical processes such as the surface sealing and accelerated by overgrazing, overcultivation, and short-term droughts.

Dr. Dixon's land imprinter can break this cycle by reestablishing the high infiltration rates necessary to replenish the soil-water reservoir required to revegetate the soil. The machine converts the smooth closed surface to a rough open one, using any existing plant material as a mulch. The mulch, in turn, not only shields the soil against falling raindrops, but also feeds small soil animals (ants, termites, etc.) which perforate the soil surface and underlying soil with their burrows.

Designed to be towed behind a tractor, the imprinter consists of two massive steel cylinders—40 inches long and 40 inches in diameter—with heavy—6-inch—angle irons welded to the surface in a variety of geometric patterns. Edges and corners of the angle irons are hard surfaced to resist abrasion wear and to self-sharpen with use.

One of the cylinders is designed to direct runoff while the other forms a seedbed for grasses. After several passes across an area of sloping rangeland, alternating rows of runoff and seedbed strips have been formed. The runoff strips concentrate or drain rainfall into the seedbed strips and in effect double the amount of rainwater available for grass seed germination and establishment.

Soil penetration by the imprinter depends on soil moisture content and the

weight of the implement. Downward force is increased by filling the cylinders with water or other fluids and by weighting the tow frame with solid steel bars.

Maximum weight of the imprinter is about 5 tons, with the water-filled cylinder and axle assembly weighing about 3 tons. The weighted tow frame weighs about 2 tons. The implement operates best when the soil is moist, yet dry enough at the surface to prevent sticking of the soil to imprint structures. Satisfactory operation requires at least a 30-horsepower tractor.

Compared to other minimum tillage implements used on croplands and rangelands, the imprinter has a slightly higher initial cost, but a lower operation and maintenance cost and much more versatility. The machine is virtually indestructible, having only the cylinder-and-axle assembly as a single moving part. Cost of imprinting should be less than half that of root plowing. Maintenance entails only the greasing of axle bearings.

An initial test of the land imprinter conducted during the summer of 1976 succeeded in revegetating two small experimental areas on the Santa Rita Experimental Range near Tucson. Sideoats grama seed quickly germinated in a seedbed prepared by the imprinter. Most of the seedlings subsequently became well established.

"The land imprinter constitutes a type of minimum tillage implement which can create infiltration control geometry and a suitable seedbed in a single pass across the land surface. The imprinter may also be used as a secondary implement in seedbed preparation following the use of conventional implements which loosen the soil," Dr. Dixon says.

"The unique and perhaps revolutionary imprinter is specifically designed to make tillage feasible in land areas not otherwise arable, including rocky, steeply-sloping, brush-covered terrain," he adds.—*J.P.D.*

Estimating Wind Erosion

WIND EROSION annually reduces wheat and grain sorghum yields on sandy soils of 2¼ Oklahoma Panhandle counties by the equivalent of total crop failure on 17 square miles.

This estimate, by ARS agricultural engineer Leon Lyles, is based on the yield reduction per inch of topsoil lost by wind erosion.

Expressing damage to land by wind erosion in terms of lost food production capacity spotlights its seriousness to the Nation and may suggest the investment in preventive measures that might be justified over the long term. No satisfactory estimate of wind erosion losses has previously been possible because many climatic, soil, and management factors collectively influence crop yields.

Dr. Lyles (204 Waters Hall, Kansas State University, Manhattan, KS 66506), explains that wind acts on many soils like a fanning mill on grain. The finer silt and clay particles are removed first, leaving behind the coarser sand and gravel. This sorting action over many years makes soils progressively coarser until they are reduced to shifting sand dunes and gravelly pavement.

To estimate the effects of wind erosion on crop production, Dr. Lyles computes potential soil loss using the ARS wind erosion equation (AGR. RES., Oct 1961, p. 8). He then uses published data from Great Plains locations relating topsoil removal (excluding fertilizer effects) to crop yield reduction.

Potential annual soil loss, according to the equation, is the combined effects of soil erodibility, soil ridge roughness, climate, the unsheltered distance across a field along the prevailing wind erosion direction, and equivalent vegetative cover.

Dr. Lyles computed potential soil loss for the eight wind erodibility groups of soil, as defined by USDA's Soil Conservation Service, for land in wheat at 20 Great Plains locations and land in sorghum at 13 locations.

He found that wind erosion at Dodge City, Kans., for example, may remove 1.11 inches of topsoil yearly from the most susceptible soils in wheat and only 0.05 inch from the least erodible soils. Corresponding potential soil losses at Dodge City for land in grain sorghum are 1.45 and 0.11 inches.

The engineer related soil loss to yield reduction by first converting published data to yield reduction in bushels per acre per inch of topsoil lost, and to percentage reduction in yield per inch of topsoil.

Applying the procedure to 1.2 million acres of cultivated sandy soils in southwest Kansas. Dr. Lyles estimated that topsoil lost annually by wind erosion cuts wheat yield 1.92, 0.69, and 0.39 bushels per acre, respectively, for soils classified as sands, loamy sands, and sandy loams—the three most erodible groups. The annual yield reduction would be 339,000 bushels of wheat and 543,000 bushels of sorghum, assuming equal amounts of land in each crop.

Dr. Lyle says his procedure appears to be today's only feasible approach to measuring the effects of wind erosion on crop production. The procedure will be usable only after more data on representative, or benchmark, soils of the Great Plains are obtained in controlled studies.—*W.W.M.*

Dr. Perdue examines an herbarium specimen—a dried, pressed portion of a plant mounted on paper—of the Ethiopian plant "koso." All these specimens, collected in 1961 in Ethiopia, are from plants which have shown anticancer activity (0277X100–19A).

Folklore and Cancer Chemotherapy

MANY CULTURES in man's history have established customs on the use of plants as medicines.

This folklore can now aid modern science in a search for plant extracts that may be useful in cancer chemotherapy, a study by botanists Robert E. Perdue, Jr., and Richard W. Spjut has shown.

Dr. Perdue and Mr. Spjut are in the Medicinal Plant Resources Laboratory (Agricultural Research Center, Beltsville, Md. 20705). One of the responsibilities of this laboratory, headed by Dr. Perdue, is to supply plant samples to the Drug Research and Development Program, National Cancer Institute (NCI).

This cooperative program between ARS and NCI was begun in 1961. ARS furnishes plant materials; NCI uses a series of bioassays that are selective for plant chemicals that might be useful for treating human cancer. Extracts that produce a significant inhibitory effect against tumor growth in laboratory animals or cancer cells in culture are designated "active." An active species is one represented by one or more active extracts; an active genus includes one or more active species.

Dr. Perdue says enough data has now been generated in this program to permit an analysis to show whether there is a correlation between plants cited in folklore and those with anticancer activity. When he and Mr. Spjut made an analysis recently, NCI had screened 20,525 species in 4,716 genera for anticancer activity, and found that 10.4 percent of the species and 26 percent of the genera yield active extracts.

The activity of plants that had been screened by NCI in this random screening program was compared with the activity of representative plants that are mentioned in folklore.

Dr. Perdue and Mr. Spjut developed lists of the folklore plants by reviewing six compendia dealing with medicinal and poisonous plants. When they compared the folklore lists with the random screen, they found that the percent of active folklore genera was consistently about double that of random-screen genera. Only one list of folklore species had a slightly lower percentage of activity than random-screen species. The percent of active species in the other five lists of folklore species was 1.4 to 2.6 times greater than that in the random screen.

"The data support the conclusion that folklore can be useful in predicting sources of antitumor activity," Dr. Perdue says. "This does not mean that folklore should be used as the only guide to screening, but it can be an additional tool."—*A.J.F.*

Toward Natural Soybean Oil

MARGARINES, salad dressings, and cooking oils with shelf lives similar to present day products and with even better nutritional quality may be made one day from nonhydrogenated soybean oil. Now, processors of soybean oil react the oil with hydrogen to repress development of off flavors.

Use of the oil in its more natural form is perceived by agricultural scientists, who have found that some new strains of soybean seeds produce oil with lower concentrations of linolenic acid than oil in soybeans grown by farmers now. This polyunsaturated fatty acid, which is essential in small amounts for humans, is several times more abundant in soybean oil than in any other major food oil, says plant physiologist Robert W. Rinne (Davenport Hall, University of Illinois, Urbana, IL 61801).

To the displeasure of both homemakers and food processors, foods containing soybean oil are likely to develop rancidity before they are consumed unless more than half of the linolenic acid is hydrogenated.

ARS soybean breeder Charles A. Brim, Raleigh, N.C., developed new soybean strains with reduced linolenic acid, on which Dr. Rinne and a former graduate student at the University of Illinois, Richard F. Wilson, conducted research.

Dr. Wilson and Dr. Rinne found that linolenic acid made up 5.1 percent of the triglyceride fatty acids in one soybean breeding line. In contrast, linolenic acid made up 7 percent of these acids in a conventional soybean variety, Dare. Triglycerides, the major components of soybean oil, are comprised of single glycerol molecules on which three fatty acids are bound.

The researchers also found that another polyunsaturated and essential fatty acid, linoleic acid, constituted 43.3 percent of triglyceride fatty acids in the low-linolenic line in contrast with 61.2 percent in Dare soybeans. But consumers may be getting less linoleic acid from hydrogenated oil of conventional varieties than they could get from unhydrogenated oil of the new varieties that may be developed from the new soybean lines, says Dr. Rinne.

He explains that hydrogenation not only saturates double chemical bonds in fatty acids, decreasing polyunsaturate levels, but it also converts some of the unsaturated fatty acid components into unnatural geometric forms called *trans* isomers. Studies are aimed at determining whether the *trans* isomers are harmful to metabolic processes in man. This research is conducted by ARS scientists at Peoria, Ill., and Beltsville, Md., in cooperation with the Georgetown University Medical School, Washington, D.C.

In other studies at the Northern Regional Research Center at Peoria, ARS scientists developed a copper-chromium catalyst that is used to a limited extent by oil processors to selectively speed hydrogenation of linolenate from presently grown commercial soybeans. Hydrogenation can be quickly terminated, leaving other components such as linoleic acid substantially unchanged.

As scientists at Urbana studied feasibility of breeding sobeans with oil that may not need hydrogenation, they found that the monounsaturated fatty acid, oleic acid, constituted about 40 percent of the fatty acids in the low linolenic line. This concentration is more than double the concentration in oil of Dare soybeans and more than half the concentration found in olive oil. The researchers also observed that the low-linolenic line contained no more of the saturated fatty acids, palmitic acid, and stearic acid than Dare and only about one-fifth as much as palm oil.

Results of the studies indicate that proportions of various fatty acids in triglyceride molecules and also the positions of those fatty acids on the molecules can be altered through plant breeding. These observations follow similar ones made by ARS chemist Evelyn J. Weber, Urbana, on corn oil (AGR. RES., Oct. 1974, p. 6).

The position of fatty acids in triglyceride molecules may be important for several reasons, the scientists say. First, oxygen reacting with polyunsaturated acids, causing rancidity, occurs least frequently when the polyunsaturated acids are bound at the middle position of the glycerol superstructure.

Second, linoleic acid bound at the middle position is likely to be used more efficiently than linoleic acid at other positions when the triglycerides are digested by man or animals.

Third, some scientists believe that fatty acid placement in the triglycerides that people consume, as well as fatty acid composition, may have a bearing on development of atherosclerosis. Atherosclerosis is a degenerative disease characterized by deposition of fatty acids in blood vessels.

ARS scientists are continuing their research on providing better soybean oil products for consumers through improved hydrogenation techniques and soybean breeding.—*G.B.H.*

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Entomologist Douglas C. Ferguson selects specimens for study from the more than 24 million insects stored in 58,000 drawers in the National Insect Collection. He is currently producing a comprehensive reference work on the tussock moths, of which the forest-destroying gypsy moth is a member (0277X147–24).

Insect Classificati

Entomologist Carl F. W. Muesebeck corrects a computer printout for a comprehensive catalog on Hymenoptera (bees, wasps, ants, and sawflies) for the United States and Canada. Though retired from USDA for over 20 years, 83-year-old Mr. Muesebeck arrives at his desk at the Museum every day at 6 a.m. and works until 1 p.m.—7 days a week. He also studies wasps and edits Russian translations of entomological publications (0277X183–25).

THE COOK who finds insects in the flour; the gardener whose prize plants are destroyed by a strange-looking caterpillar; and the forester who collects larvae from dying trees, all have a common problem—determining what the pest is and how to get rid of it.

Answering the question "What insect is it?" is an important part of the work of ARS entomologists in the Systematic Entomology Laboratory (SEL), a part of the Insect Identification and Beneficial Insect Introduction Institute situated at the National Museum in Washington, D.C., and at Beltsville, Md. These research scientists provide an indispensable service not only to farmers and the general public, but also to plant inspectors, biological control researchers, and many other scientists who need to know the identity of a particular insect or mite.

The SEL scientists identify from 250,000 to 350,000 insect and mite specimens every year. Specimens vary from carefully preserved and packaged insects sent in by a scientist searching for foreign beneficial insects to an envelope containing insect fragments from an irate gardener.

Accurate identification of any insect is necessary before its potential destructiveness or value can be determined. Without accurate identification, costly mistakes can be made in control measures or in unjustified or ineffective quarantine procedures. The basis for accurate identification of the estimated 10 million insect species (only 1 million of which have been described) lies in classification, the primary work conducted by the 29 SEL entomologists.

As new pests are introduced into this country or old pests suddenly become prolific, the classification of these insects becomes increasingly complicated. The SEL entomologists study all groups of insects and mites but concentrate their efforts on pests of economic importance to crops, forests, man, ani-

With the scanning electron microscope, researchers can view the three dimensional surface structure of minuscule objects in detail never before possible. This formidable "face" belongs to Chelonus marayani, a parasite of Heliothis—a major pest of cotton, corn, and other crops (PN–4129).

This tiny (5-mm long) parasitic wasp from Iran, Praon barbatum, may be a valuable biological control agent against the pea aphid, a pest of alfalfa and other legumes. The wasp was sent to SEL for positive identification. Entomologist Paul Marsh, who specializes in parasitic wasps, compared the specimens with museum collections and existing literature to prove that it was indeed Praon barbatum. If an insect is not found in these references, it is described, named, and added to entomological literature (0676X685–19).

n: Key to Control

mals, and beneficial insect species. This limitation, however, does not greatly reduce the work of classification since the insects having the greatest economic importance—namely the flies, beetles, moths, hymenoptera (ants, bees, wasps, and sawflies), and true bugs—are the largest groups.

The scientists often need to limit the scope of their research to a single order, superfamily, or family such as flies, grasshoppers, or scale insects. Such specialization is essential for the thoroughly competent and authoritative work needed in the identification and classification of insects.

Not only do the large number of species of insects pose a problem, but the complex life cycles of the insects themselves make classification difficult.

"Newborn mammals are often miniature look-alikes of their parents," says entomologist Ronald W. Hodges, Chief of the SEL (Rm. 2, Building 003, BARC-West, Beltsville, MD 20705), "but insects may have up to four stages in their life cycles, none resembling the other.

"The beautiful monarch butterfly, for example, bears little resemblance to its earlier stages as an egg, a caterpillar, or a hard-shelled pupa."

The SEL entomologists must be able to distinguish among differences that place an insect in a distinct species as well as individual differences within a species. As Dr. Hodges puts it, "Just as we recognize all dogs as dogs, we also recognize that there are groups of dogs such as basset hounds and poodles and that within these groups there are individuals who look a bit different from each other, but still belong to that group. So it is with insects. We, as entomologists, must be able to recognize differences that separate species from differences that separate individuals within a species.

"Another complicating aspect of insect identification is polymorphism, or

Entomologist Raymond J. Gagné with some of the major research "products" of the Systematic Entomology Laboratory. He is examining a color plate from a definitive USDA-supported work on the moths of North America—one of the latest entries in a priceless collection of entomological literature spanning two centuries that is housed in a joint Smithsonian-USDA library at the Institution's Museum of Natural History (0277X148–19A).

Each year scientists at the Systematic Entomology Laboratory identify almost 350,000 insect specimens submitted from around the world. Dr. Hodges is working on Lepidoptera, *his research speciality, of which are some 140,000 described species (0576X609–33).*

differences among individuals of the same species. The winged sex forms in termites and ants bear little resemblance to the sex forms of the wingless workers in the same species. Entomologists must be able to recognize that these are not separate species, but one and the same."

To aid them in their work, the SEL scientists help maintain an outstanding library and the National Insect Collection with over 24 million specimens. Because of the comprehensiveness of the library and collection, requests for identification of insects coming from abroad as well as the United States, can be authoritatively answered.

Confirmation of new pests, either new to this country or new to a particular area of the country, is an important part of the work of the SEL entomologists. Positive identification of an insect is necessary before eradication methods can get underway.

Recently, SEL scientists confirmed the presence of the gypsy moth in California, thus enabling the use of Federal funds to promptly help eradicate the infestation.

The early identification by an SEL scientist of the highly destructive Mediterranean fruit fly from backyard orange trees in Miami, Fla., in 1958 led to the quick eradication of that pest before it could destroy local commercial citrus orchards.

Because of their vast knowledge, the SEL scientists are also at work on such diverse projects as a book on the moths of America north of Mexico and a manual for the Food and Drug Administration to be used in the identification of insect fragments in food. The main research objective is the accurate classification of the estimated 10 million species of insects, a job which, says Dr. Hodges, "will keep us all very busy, for a long time."—*M.E.N.*

The subtle differences—and similarities—in these greatly magnified (250X) photomicrographs of the external sex organs, or genitalia, of Lepidoptera *aid Dr. Hodges in his studies. Entomologists often find that an insect species can be more accurately defined by its genital characteristics than by its shape, size, color, and wing pattern (0277X144–18A).*

To determine the amount of water removed by the heat recovery system, Dr. Lai measures the wet bulb and dry bulb temperatures of the exhaust air (0177X047–30).

Recovering and Reusing Heat

Should fuel prices rise high enough to justify the added equipment costs, the energy requirement for drying grain might be cut 40 to 50 percent by recovering and reusing heat.

Teaming a heat-pipe heat exchanger and a heat pump with a batch-type dryer, as in preliminary tests at the U.S. Grain Marketing Research Center (1515 College Ave., Manhattan, KS 66502), wouldn't be practical today, says ARS chemical engineer Fang S. Lai.

He says the investment in heat recovery systems might be justified if dryer operating costs should significantly exceed ownership costs.

Grain drying is one of the largest agricultural uses of energy. In the Corn Belt, where nearly three-quarters of the corn is artificially dried at harvest to prevent spoilage in storage, about as much energy is used in drying as in producing the crop.

Engineers 20 years ago demonstrated the feasibility of conditioning air with a heat pump for drying grain, but the high initial cost of equipment prevented application. The heat-pipe heat exchanger, likewise expensive, had not previously been used in grain drying.

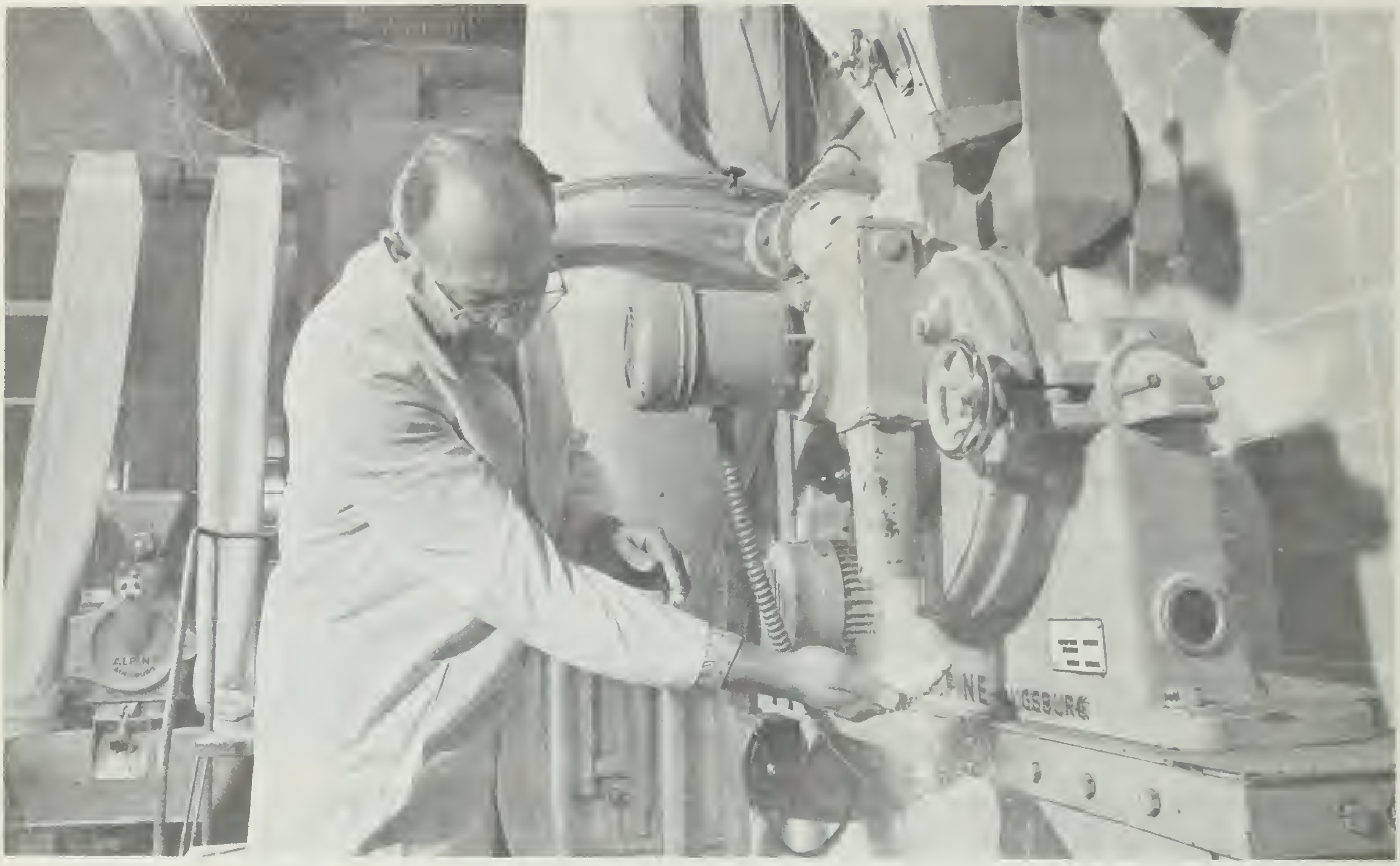
Dr. Lai and agricultural engineer George H. Foster tested the heat recovery systems in reducing moisture content of corn from 25 to 15 percent in a laboratory batch grain dryer. With both the heat pump and heat exchanger, 42 to 46 percent less energy was used in drying than without heat recovery. The reduction was 6 to 10 percent with the heat exchanger only.

The heat-pipe heat exchanger consists of two chambers, side by side. Thermal energy is transferred rapidly from a hot airstream on one side to a cool airstream on the other by evaporation and condensation of fluid in several rows of pipes between the two chambers. In the heat pump, energy is added to refrigerant from warm air in the evaporator, and the refrigerant is pumped to the condenser where energy is transferred to reheat the air.

In the experiments, hot air from the dryer passed directly to the high-temperature side of the heat exchanger, where a substantial amount of heat was removed. The air then moved to the evaporation coil of the heat pump to lose additional heat.

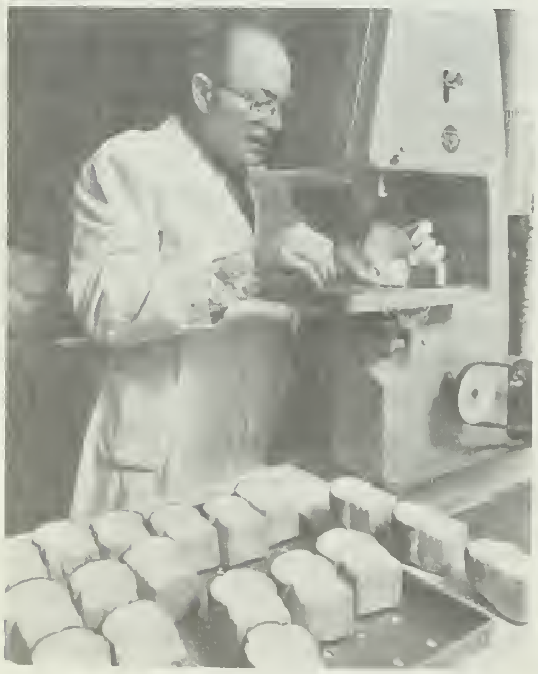
At this point, Dr. Lai explains, the cooled air was recycled to the low-temperature side of the heat exchanger to pick up transferred heat in some tests. In others, cooled air was exhausted to the atmosphere, and ambient air was drawn into the low-temperature side of the exchanger. In either case, warmed air then moved to the dryer fan and was forced over the heat pump's condensing unit to pick up heat taken from exhaust air by the evaporator. Finally, the air moved across electric resistance heaters into the corn.

All units, ducts, and enclosures in the system were covered with 1-inch blanket-type insulation to restrict heat loss.—*W.W.M.*



Dr. Shuey examines the coarse fraction flour being expelled from the air classifier during separation. The air classifier makes a density separation of the fine ground flour by the use of an air stream (0177X042–15).

Better Bread with Managed Flour



Products baked with managed flour are evaluated against a known standard of performance. Dr. Shuey slices loaves of bread for evaluation of grain and texture (0177X044–8).

Baking characteristics of wheat flour can be improved, and flour modified to meet special needs, by incorporating additional steps in the milling process.

Bakers faced with using wheat that doesn't fully meet their specifications may partially overcome deficiencies by adjustments in the production process. Or they may blend a better wheat into a poorer one.

Another alternative, says food technologist Joel W. Dick, is to produce what he calls "managed flour." This involves partially taking apart the flour from less desirable wheat and blending selected components to produce a flour having baking characteristics superior to those of the original straight-grade flour.

In conventional roller milling, explains Dr. Dick, flour is recovered in a succession of flow streams—17 on the pilot mill at Fargo, N. Dak. The streams, derived from different parts of the wheat kernel, vary in composition but ordinarily are combined as straight-run flour.

In producing a managed flour, Dr. Dick, ARS food technologist William C. Shuey (106 Harris Hall, North Dakota State University, Fargo, ND 58102), and Orville J. Banasik of North Dakota State University selected flour from 8 of the 17 flow streams. They separately pin-milled each to reduce flour particle size.

Then each flour was separated into three fractions—high protein fine, low protein fine, and intermediate protein coarse by a process called air classification. The researchers then selected frac-

tions on the basis of potential for modifying undesirable characteristics and blended them with the remainder of the flour produced by roller milling.

The procedure could extend the usefulness of semidwarf hard red spring wheats, Dr. Dick says. Semidwarf varieties often excel those of conventional height in agronomic traits, but some are marginal in baking characteristics.

A study with the semidwarf varieties Era and Red River 68 demonstrated how baking characteristics might be improved in a managed flour from these wheats. For Era, the objective was to increase percent absorption of water by flour and maintain or slightly lengthen peak mixing time. In contrast, improving the quality of Red River 68 flour involved shortening mixing time and maintaining or increasing absorption.

Both desired changes were accomplished in two of four managed flour blends from Era and one of four from Red River 68, Dr. Dick reports. The two improved Era blends had 1.1 and 2.2 percent higher absorption, as indicated by farinograph readings, and 1 minute longer mixing time. In the Red River blend mixing time was reduced 2 minutes and absorption increased 0.4 percent. Further studies should increase the researchers' ability to produce the desired modification.

The study also indicated the opportunity for producing a managed flour higher in protein than the original, Dr. Dick says.

From the highest protein flour stream, the high protein fine fraction after air classification was 3.7 percent higher than the original Era flour and 2.6 percent higher for Red River 68. Protein content for a managed flour might be raised by including this high protein fraction in a blend.

Another possibility, says Dr. Dick, would be to produce a managed flour with characteristics unlike those of available flours but useful in new food products.—*W.W.M.*

The Sturdy Oak

RESISTANCE to oak wilt disease, for the first time, has been observed in red oak seedlings. The screening procedure which scientists developed and used to identify the resistant seedlings may help insure that red oaks remain prominent in the eastern half of the Nation, providing beauty and shade in urban and rural settings. But science has yet to find a way to insure that the species remains as an important hardwood lumber tree.

From more than a thousand seedlings tested, ARS and University of Wisconsin scientists screened out 17 resistant seedlings. "These seedlings developed no oak wilt symptoms after we used a hypodermic needle to inoculate them with the fungal disease-causing organism in 3 successive years," says ARS plant pathologist Richard D. Durbin (Disease Resistance Laboratory, University of Wisconsin, Madison, WI 53706). Further research is being conducted to find whether the seedlings may still succumb to infections by natural agents such as beetles.

Efforts to identify resistant red oaks in nature are hampered because exacting conditions necessary for disease spread may not be present at many times, says Dr. Durbin. The preliminary screening procedure makes testing of large numbers of seedlings possible in the greenhouse.

"If the promising results of our screening are further confirmed, resistant red oaks could be multiplied in sufficient number for the nursery trade within a few years," says Dr. Durbin. But some basic stumbling blocks must be overcome before they can be increased in large numbers.

In their search for ways to mass-produce the disease-resistant red oaks, the scientists are trying to develop several vegetative techniques, including tissue culturing and rooting. "Reproducing the red oaks sexually is not a viable alternative," says Dr. Durbin, "because we would have to wait 30 or 40 years for the trees to develop sexual maturity." Genetically, red oak trees are so complex or heterogeneous that many of the offspring would not be resistant anyway.

New techniques for vegetatively propagating the resistant oaks—if they can be developed soon—will be most timely. Dr. Durbin notes that oak wilt has spread alarmingly during the past three decades in Eastern and Central States where oaks are the leading hardwood timber species and also important as shade trees. Some researchers have predicted that within the next 30 years about half of the Nation's oak trees will be afflicted.

The oak seedlings which Dr. Durbin and his colleagues screened for disease resistance were grown from seeds collected at 18 locations in 8 Wisconsin counties in different years. Some collections came from single trees, but most collections were pools of seed from 5 to 10 trees. "We grew 11 of the 17 resistant seedlings from seeds that were collected from one site in Dane County," says Dr. Durbin.—*G.B.H.*

Mr. Wardecker covers beehives with burlap prior to insecticide spraying. The covers were the most successful single treatment for preventing losses, however, a combination of treatments proved most effective (0277X173–34A).

Good News for Beekeepers

INSECT OUTBREAKS in cotton, alfalfa, and other crops many times spell doom for colonies of foraging honey bees. Doom—because about the only recourse growers have of controlling such outbreaks is applying insecticides. And it is the contact-insecticide that takes its toll of bee colonies.

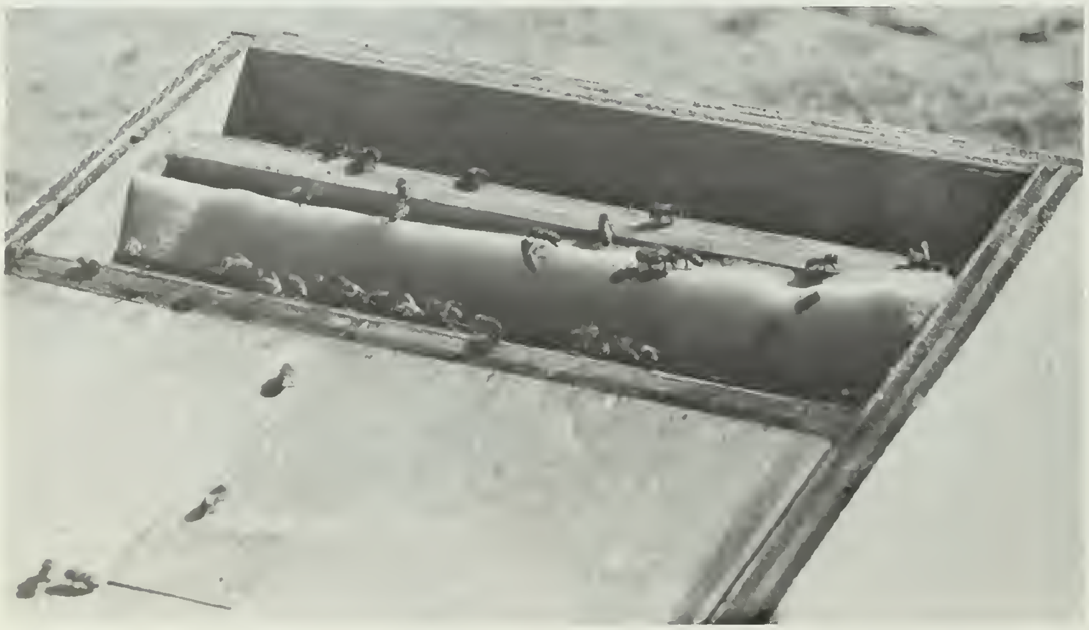
All that could change, however, with recent findings at ARS bee research laboratories at Tucson, Ariz., and Laramie, Wyo., where scientists have developed a method of protecting the bees before and after insecticide applications.

Beekeepers in Arizona and Southern California one recent year suffered severe losses when an outbreak of pink bollworm on cotton caused a large increase in the use of insecticides. It was estimated that 70,000 colonies of bees were killed or damaged that year in California alone from repeated spraying.

Some years, cotton is sprayed 15 or more times at 5- to 7-day intervals in the Salt River Valley of Arizona. Because of this spraying, the number of colonies of bees in the State dropped by more than half—from 110,000 in 1964 to 53,000 in 1971—and colonies were virtually eliminated in many cotton areas of Arizona.

ARS scientists at Tucson and Laramie are in the midst of a study designed to eliminate these losses. The study is particularly timely now since bees are playing an increasingly important role in cotton production.

Cotton growers are looking more and more to bees to pollinate the significant Pima cotton crop and when hybrid cotton becomes practical, it will be bees that play the important pollination role in the production of hybrid seed. Other countries use hand labor to produce hybrid seed. Labor costs here al-



The waterer sits on top of the hive, contains approximately 3 gallons of water, and is constructed of wood and foam rubber (0277X172–14).

most rule out manual pollination.

It is impractical to move bee colonies during spraying operations not only because of the frequency of the applications but because there is really no place to move them.

With that in mind, entomologists Joseph O. Moffett, Bee Research Laboratory (2000 E. Allen Road, Tucson, AZ 85719), Adair Stoner, Lonnie N. Standifer, and William T. Wilson devised 16 treatments to protect bees from insecticides.

The researchers used a 480-acre planting of cotton in which to place the colonies—10 colonies to each treatment. That field underwent five insecticide applications during the time of the trials last summer.

The most effective treatment among the 16 was a 6-way combination which included burlap covering, pollen feeding, shade, top waterer, bottom board, and sirup feeding.

Since the colonies did not take sirup during most of the test, sirup feeding could probably be eliminated from this treatment.

Burlap covering confines the bees to the hive—until 12 hours after the insecticide application—while the pollen and water sustain them for the period of confinement.

The shade keeps them out of the hot Arizona sun and the bottom board—which gives bees additional room at the bottom of the hive—provides a clustering space for field bees at night and during heat waves or confinement when they cannot fly.

Not only did the 10 colonies in this treatment survive, they gained weight and were strong after the five insecticide applications that started in late July and ended in mid-September.

Most of the colonies in the other treatments—single or combination treatments of the above—were either killed or reduced to one or two frames of bees per colony with the exception of those covered with burlap. Most of the burlap-covered colonies survived but lost weight.—*J.P.D.*

Saving Valuable Protein

Some grain legumes and the lathyrus pea (*Lathyrus sativus*) in particular are known to contain substances toxic to humans and animals. Related to the sweet pea, the lathyrus pea is a small, hardy, drought-resistant legume with a protein content of 25 percent.

Also called khesari in India where it has been extensively grown, lathyrus can cause irreversible paralysis of the legs—a disease called lathyrism—if it constitutes over 25 percent of the diet. The consumption of khesari has been directly attributed to epidemic outbreaks of this disease in large areas of India, especially when cereal crops fail. This has become a matter of public concern in India and of subsequent action to prohibit cultivation of what would otherwise be a valuable commodity.

However, as a result of Indian research, partly sponsored by ARS, there is now the potential for saving khesari and its abundant source of protein. The Indian scientists have found that lathyrism is caused by Beta-N-Oxalyl Amino Alanine (BOAA), a toxic amino acid in the plant's protein.

Since the BOAA content varies in lathyrus varieties, the Indians identified low BOAA lines by chemical analysis. Those lines low in toxin were multiplied and tested for yielding ability and low toxin content at a number of locations with varying environments. Breeders are continuing efforts to imprint these varieties with identifying physical traits through incorporation of genetic markers. The Indian scientists also discovered a male sterility trait in the species, which will facilitate the breeding of better varieties.

A major result of their work is a variety called Pusa-24 that is low in BOAA content (0.20 percent). BOAA content of varieties tested ranged from 0.10 to highly toxic 1.28 percent.

In bioassay tests the Indians found that symptoms could be produced in chicks with BOAA extracted from 5 to 6 grams of khesari seeds of normal variety. Normal varieties contain approximately 0.42 percent BOAA. With Pusa-24, however, an extract from 24 grams was required to produce similar symptoms, confirming biologically the results of the chemical tests.

As a result of these tests and other observations, Pusa-24 has been declared relatively safe by the Indian National Institute of Nutrition, Hyderabad, and has been recommended to Indian farmers.

Plant pathologist Jack P. Meiners, Agricultural Research Center (Beltsville, MD 20705), ARS-cooperating scientist, says benefits to U.S. agriculture from this project are indirect.

"The major result," he says, "is the potential of a safe, high-protein, high-yielding crop for countries where seasonal and climatic conditions may in certain years preclude the growing of cereal crops. By the year 2000, when the population will have increased to 6.5 billion, the world will need to double its protein supplies."

This Public Law 480 project was conducted at the Indian Agricultural Research Institute, New Delhi, under the direction of Dr. H. K. Jain.—*M.C.G.*

Right: Prior to determining their fresh weight, Dr. Snyder removes leaf blades from young sugarbeet plants. Fresh weight is the denominator by which the taproot growth partitioning ratio is determined (0277X102-8). ***Below:*** *The taproot weight, less the petiols pictured here, is the numerator of the equation (0277X103-2).*

Genetics Points the Way

SUGARBEETS may some day produce higher yields by distributing more dry plant matter into the root. Recent studies by plant pathologist Freeman W. Snyder and agronomist Gerald E. Carlson, Light and Plant Growth Laboratory (Agricultural Research Center, Beltsville, MD 20705), have shown that some sugarbeet plants are more efficient than others in converting light into plant matter in the sugarbeet root and that this difference in efficiency can be genetically controlled.

For these studies Dr. Snyder grew sugarbeets in growth chambers under carefully controlled light, temperature, and mineral nutrition. Twenty-one days after the seedlings emerged, the plants were harvested and the fresh weight of leaf blades and of the taproot with the attached shoot growing-point was determined.

Dr. Snyder then calculated the ratio of taproot to leaf blade weight and selected plants with the largest and smallest proportions of taproot for seed production.

He found that the proportion of taproot to leaf blade weight of individual plants may differ more than twofold. Repeated selection established that the proportion of taproot to leaf blades is a heritable trait.

The two sugarbeet populations developed through this selection process differed by 65 percent in partitioning of photosynthate to the taproot. These populations will aid in verifying some of the physiological principles used in predicting crop yield, particularly in determining the magnitude of the increase that photosynthate partitioning can contribute to yield of the usable portion of the crop.

Dr. Snyder and Dr. Carlson theorize that a population that partitions relatively more dry matter to the taproot should yield more tons of roots per acre than one that partitions less. If further tests support these preliminary findings, then this new selection technique should help plant breeders to develop higher yielding varieties of sugarbeets.—*J.P.O.*

Quick and easy cover

QUICK-GROWING ANNUAL GRASSES can give good temporary protection against soil erosion on newly graded sites.

Until permanent cover is established, which may take months, on erosion-susceptible sites such as newly graded highways, spillways, and earth dams, annual grasses such as sudangrass and wheat can be planted immediately after construction and give protection in a matter of days.

These quick-growing grasses can protect the sites until permanent vegetation is established. Without this protection, frequent, light rainstorms can cause undesirable rills and deposits.

Flow tests were conducted by a team of researchers headed by ARS hydraulic engineer William O. Ree, Water Conservation Structures Laboratory (P.O. Box 551, Stillwater, OK 74074), and including professors Franklin R. Crow and Wayne W. Huffine of Oklahoma State University. Tests showed that sudangrass can provide protection as quickly as 10 days from seeding. The protection increases with plant age, and the degree of protection is also influenced by plant densities, heights, and planting arrangements.

Wheat also gives good protection; however, the scientists point out that the type of annual grass to be planted would depend on the location of the site and the season of the year.

The extensive data that the scientists gathered will be very useful to those seeking to protect the environment from erosion at construction sites. This erosion not only damages the sites themselves, but contributes to the sedimentation of rivers, lakes, and streams. Such sedimentation is the most serious water pollution problem in the United States today.—*B.D.C.*

Don't forget the zinc

CORRECTING a zinc deficiency in the diet of rangeland cattle could mean a 22-million-pound increase in annual western beef production at a material cost of only 20 cents per animal each year.

In 1975, approximately 23 million beef calves were born in the 17 Western States. The grass forage of these calves and their mothers contained as little as 5 parts per million (p/m) of zinc when mature. Though the precise zinc requirements of ruminants are uncertain, soil scientist Henry F. Mayland, Snake River Conservation Research Center (Route 1, Box 186, Kimberly, ID 83341), suspected that 5 p/m was inadequate and, as a result, cattle weight-gain was impaired.

To test this idea, Dr. Mayland has been studying 100 to 120 predominantly Hereford, cow-calf pairs on the Saylor Creek Experimental Range, near Glenns Ferry, Idaho. The animals were conditioned on cheatgrass during a 72-day breeding period and then separated by weight, sex, and owner into 10 groups. For 150 days, half the pairs in each group received a daily 0.9-gram zinc supplement in addition to their normal diet, while the other half received no zinc supplement.

In the first year of the study, calves given the zinc gained 18 pounds more than the other calves. During the second year of the study, the increase was 11 pounds more. In the yet to be completed third year of the study, zinc-supplemented calves continue to outgain their counterparts.

Though no visible symptoms of zinc deficiency were detected in cow-calf pairs that were not given a zinc supplement, it is known that zinc deficiency in pregnant animals can cause difficulty in giving birth and may impair the offspring's ability to learn. Zinc deficiency has also caused some dwarfing in humans in the Middle East.

Besides enhancing weight gain, an adequate supply of zinc in most animal diets also enhances wound-healing and sexual development, increases litter size of rabbits and rats, and improves the ability of ruminants to convert plant protein into animal protein (AGR. RES., 1975, p. 7).

The weight-gain responses to zinc supplements in Dr. Maryland's study indicate that some range cattle are not getting enough zinc in their forage; that the situation can be corrected; and that both ranchers and consumers would benefit from doing so.—*L.C.Y.*

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Dim the lights

WINDOWLESS HOUSES and total light control can help achieve maximum efficiency in broiler production.

Two ARS researchers found that controlled lighting led to as much as 10 percent improvement in feed conversion and produced as much or more meat as conventional window or curtain types of broiler houses.

Animal scientist James W. Deaton and agricultural engineer Floyd Reece, South Central Poultry Research Laboratory (Mississippi State, MS 39762), experimented with both continuous low-light intensity and short-term intermittent lighting in control chambers. Both procedures give improved feed conversion; however, an intermittent light-dark regime of 15 minutes of light at 13 lux (dim light) and 1 hour and 45 minutes of darkness produced the best results.

But the researchers emphasize that during the first 2 weeks of production, the chicks should be given continuous light at about 65 lux so they can locate feeders and waterers.

"The apparent reason for the better feed conversion," says Dr. Deaton, "is that bright light causes the birds to be more active and thus use up more energy that would otherwise be converted to body weight."

One problem with the windowless house is overheating during hot summer months. A possible compromise, the researchers say, is to build broiler houses with collapsible panel sidewalls. Such houses could be operated windowless during fall, winter and spring, and opened for ventilation during the summer.—*B.D.C.*

Stretching apples into shape

AS A RESULT of an experiment that did not quite work, chemicals will soon be on the market to improve the shape of Red Delicious apples grown in warm climates.

Consumers tend to favor the familiar, and since most Red Delicious apples come from Washington, where apples have an elongated shape, most people seem to prefer their Red Delicious apples elongated. But in areas of the country warmer than Washington, Delicious apples grow round.

ARS plant physiologist Max W. Williams (Box 99, P.O. Annex 111, Wenatchee, WA 98801), was attempting to increase the fruit set of Delicious apples through the use of chemicals. Among the chemicals tried was a combination of gibberellins and the cytokinin 6-purine. Fruit set did not increase except on emasculated flowers, but Dr. Williams did note a pronounced lengthening of the apples' calyx end.

Trials were repeated in New Zealand with similar results, and Dr. Williams' work spurred further research in North and South Carolina, Michigan, and other States wanting to shed their round-apple status.

Test apples from these States have shown a marked improvement in their length-to-diameter ratio, plus an increase in fruit volume.

A commercial product is now being developed, and it seems that soon all Red Delicious apples can be chemically altered to display the preferred "Washington" shape.—*L.C.Y.*

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